

MEMORANDUM | November 13, 2015

TO Kristine Koch, U.S. Environmental Protection Agency (EPA)
FROM Tom Fredette, Rita Cabral, and Gail Fricano, Industrial Economics, Inc.
SUBJECT Suggestions for Quantitative Analyses to Support the Portland Harbor Feasibility Study

This memorandum provides comments on behalf of the Five Tribes¹ on potential additional quantitative analyses for Section 4 of the Draft Portland Harbor Feasibility Study (FS). Our previous comments to EPA on Section 4 of the FS (dated September 24, 2015) note this section would be strengthened by more quantitative analyses and stronger data visualization. At your request, below we present examples of analyses and graphics that may help the reader evaluate and compare the alternatives. We urge you to consider whether these examples would be useful and appropriate for Section 4 and to include any such analyses in the revised Section 4.

This memorandum does not include recommendations for a natural recovery model, which we highlight as another data gap in our previous Section 4 comments.

SECTION 4 RECOMMENDATIONS

Section 3 of the FS is generally robust and clearly presents quantitative analyses. Section 4 presents a more qualitative comparison that does not take full advantage of the analyses underlying Sections 3 and 4. Inclusion of relatively simple analyses would make Section 4 more accessible, and assist in supporting the eventual selection of a remedy.

We recommend that EPA use more graphical comparisons and summary tables to demonstrate the differences among the alternatives. Section 4 already includes information on the projected reductions in surface weighted average concentrations (SWACs), achievement of Preliminary Remediation Goals (PRGs), and other such quantitative data. Although these data are provided in tables and text, the information is often difficult to compare across alternatives and is not fully utilized in Section 4. In Exhibits 1 and 2, we present two simple examples of useful graphical comparisons. These figures compare SWAC reductions among the alternatives using data provided in Section 4 text. Exhibits 1 and 2 illustrate the projected percent SWAC reductions relative to Alternative A and Alternative B, respectively. Data presentations such as these improve the ability of stakeholders to comprehend the data and differences between alternatives.

¹ The five tribes are the Confederated Tribes of The Grand Ronde Community of Oregon, the Nez Perce Tribe, the Confederated Tribes of Siletz Indians, the Confederated Tribes of the Umatilla Indian Reservation, and the Confederated Tribes of the Warm Springs Reservation of Oregon.

EXHIBIT 1 PERCENT SWAC REDUCTIONS RELATIVE TO ALTERNATIVE A

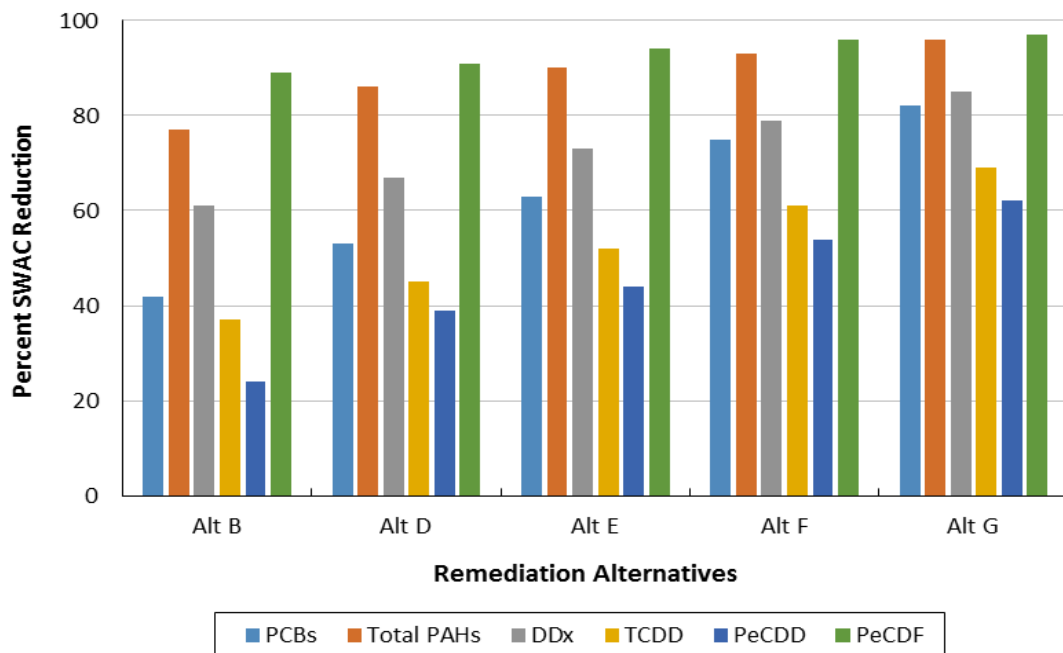
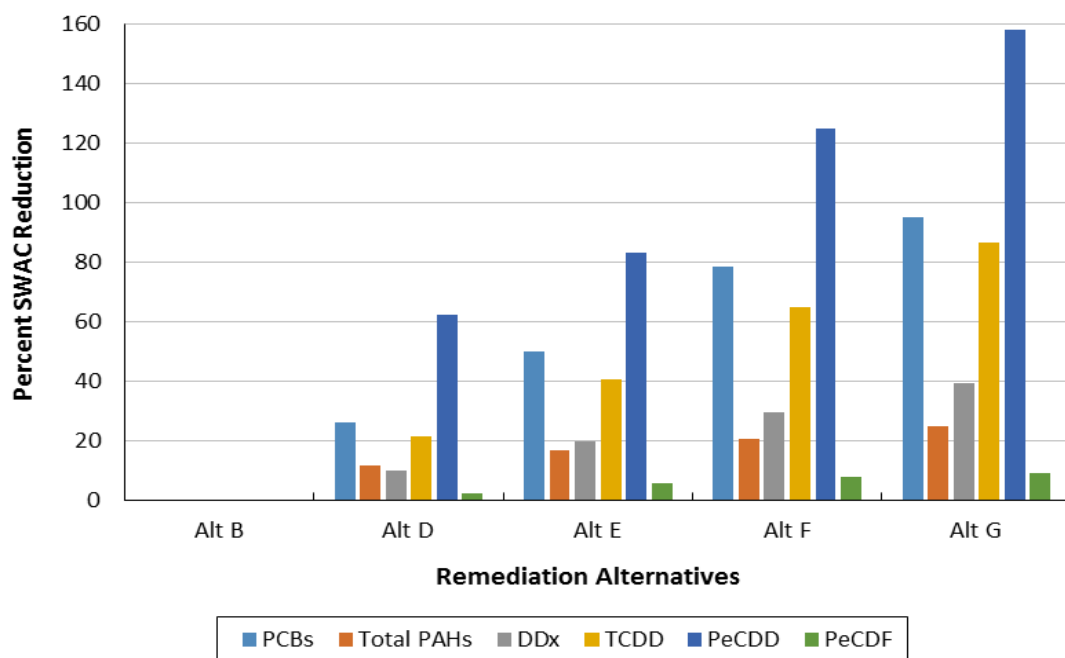


EXHIBIT 2 PERCENT SWAC REDUCTIONS RELATIVE TO ALTERNATIVE B



Below, we provide examples of quantitative analyses that were used in FSs for other sediment remediation sites and that may be useful for the Portland Harbor FS. We have not performed a side-by-side analysis to determine if the approaches can be directly applied to the data collected from the Portland Harbor site. However, because a considerable amount of quantitative data have been generated as part of the Portland Harbor FS process, the methods used at other Superfund sites can likely be modified and utilized to bolster Section 4.

Lower Duwamish Waterway, WA

The Lower Duwamish Waterway FS includes a graphical timeline, summary tables, and quantitative graphics that help elucidate the differences between alternatives (see Exhibits 3 and 4 and Attachment A for examples; AECOM 2012). These types of analyses may be useful for the Portland Harbor FS.

EXHIBIT 3 TIME TO ACHIEVE CLEANUP OBJECTIVES FOR RAOS FOR ALL ALTERNATIVES (FIGURE 10-4 IN AECOM 2012)

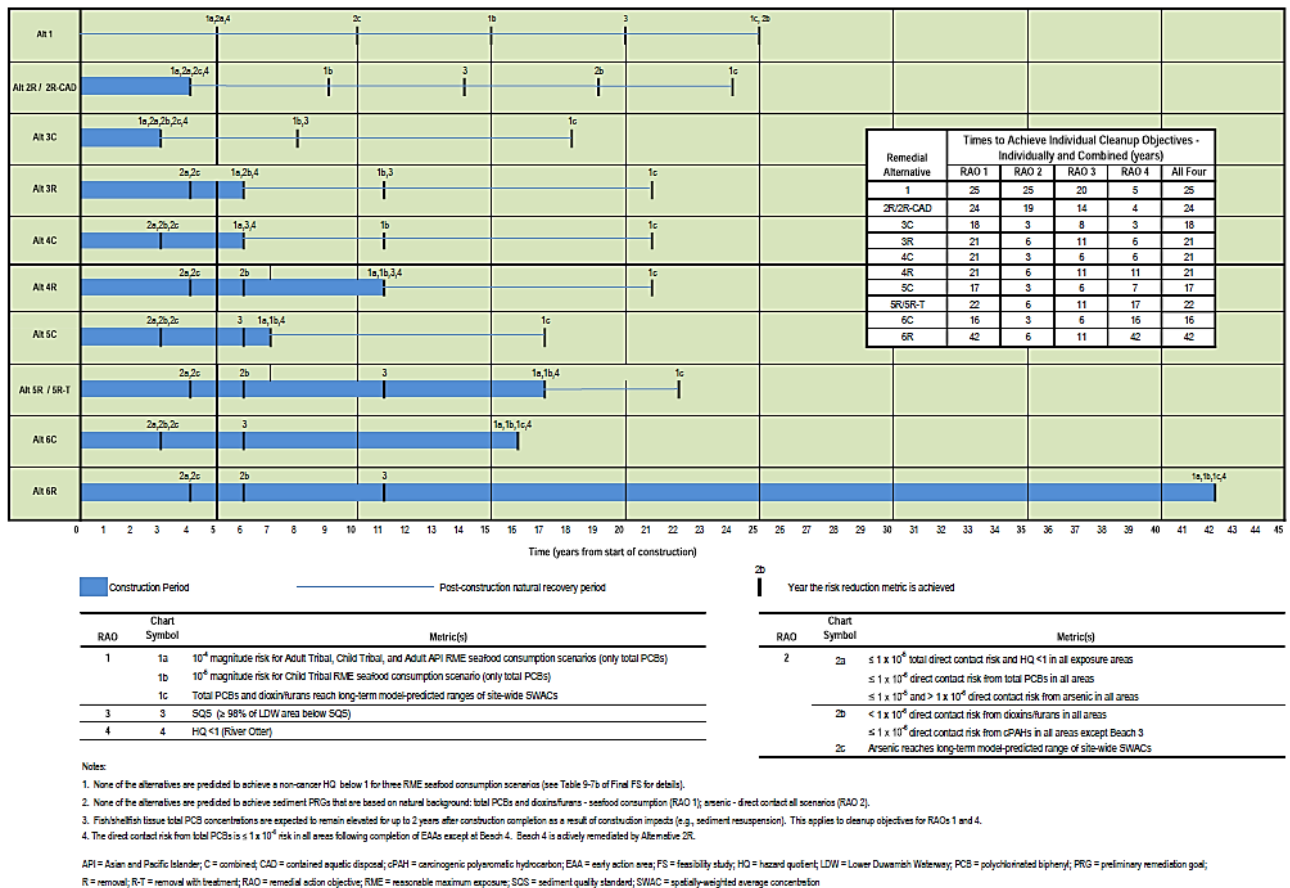
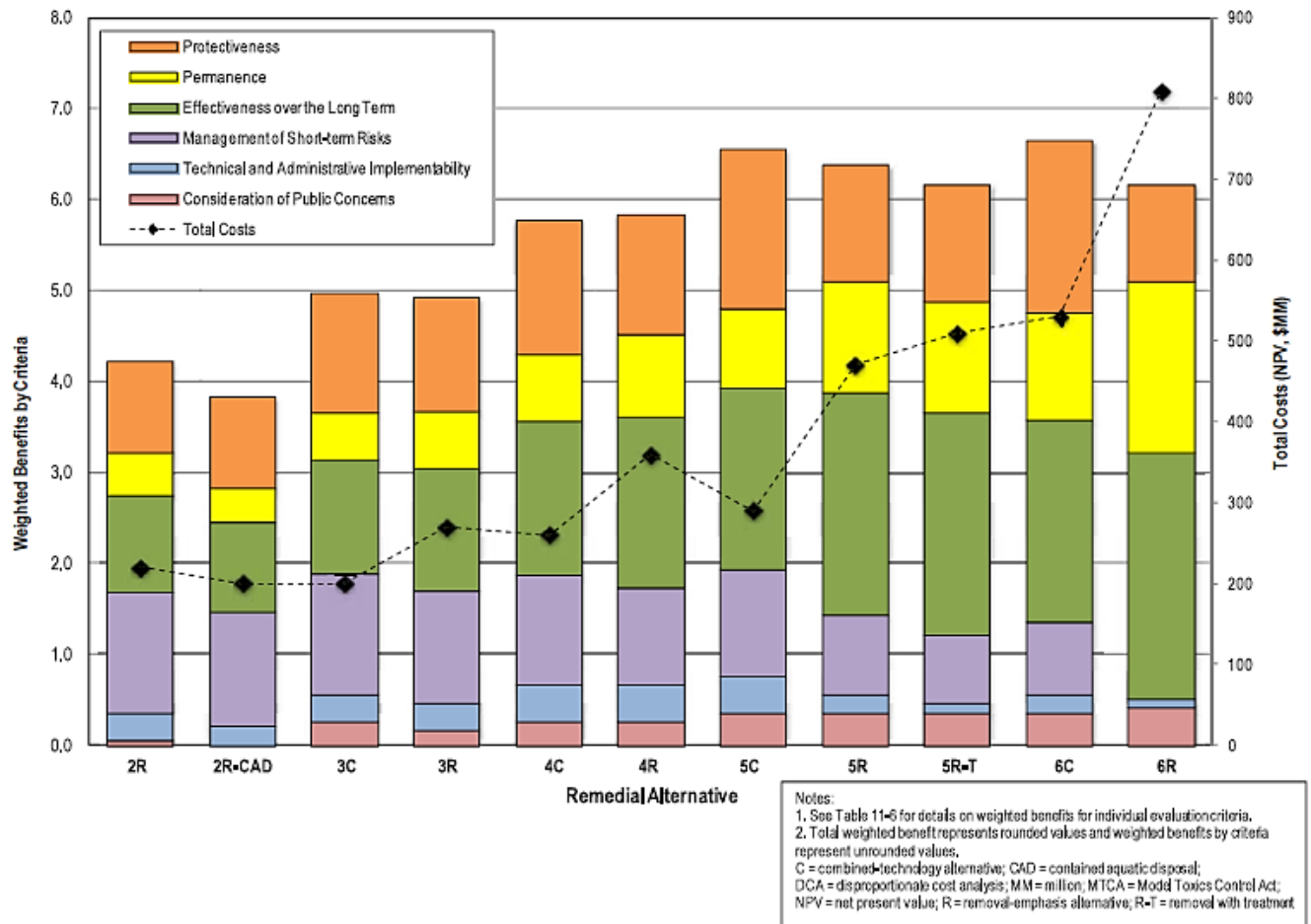


EXHIBIT 4 MODEL TOXICS CONTROL ACT DISPROPORTIONATE COST ANALYSIS WEIGHTED BENEFITS BY CRITERIA AND ASSOCIATED COSTS FOR THE REMEDIAL ALTERNATIVES (FIGURE 12-2 IN AECOM 2012)



Hudson River, NY

The Hudson River FS provides quantitative summary table comparisons of alternatives relative to ecological and human health improvements (Exhibit 5 and Attachment B; TAMS Consultants 2000), which may be useful for the Portland Harbor FS. In contrast, the current Portland Harbor FS often states that one alternative will be better, faster, or greater than another without providing a numerical assignment to the descriptor.

EXHIBIT 5 TIME TO REACH FISH TARGET LEVELS (SECTION 9.1.1.1 IN TAMS CONSULTANTS 2000)

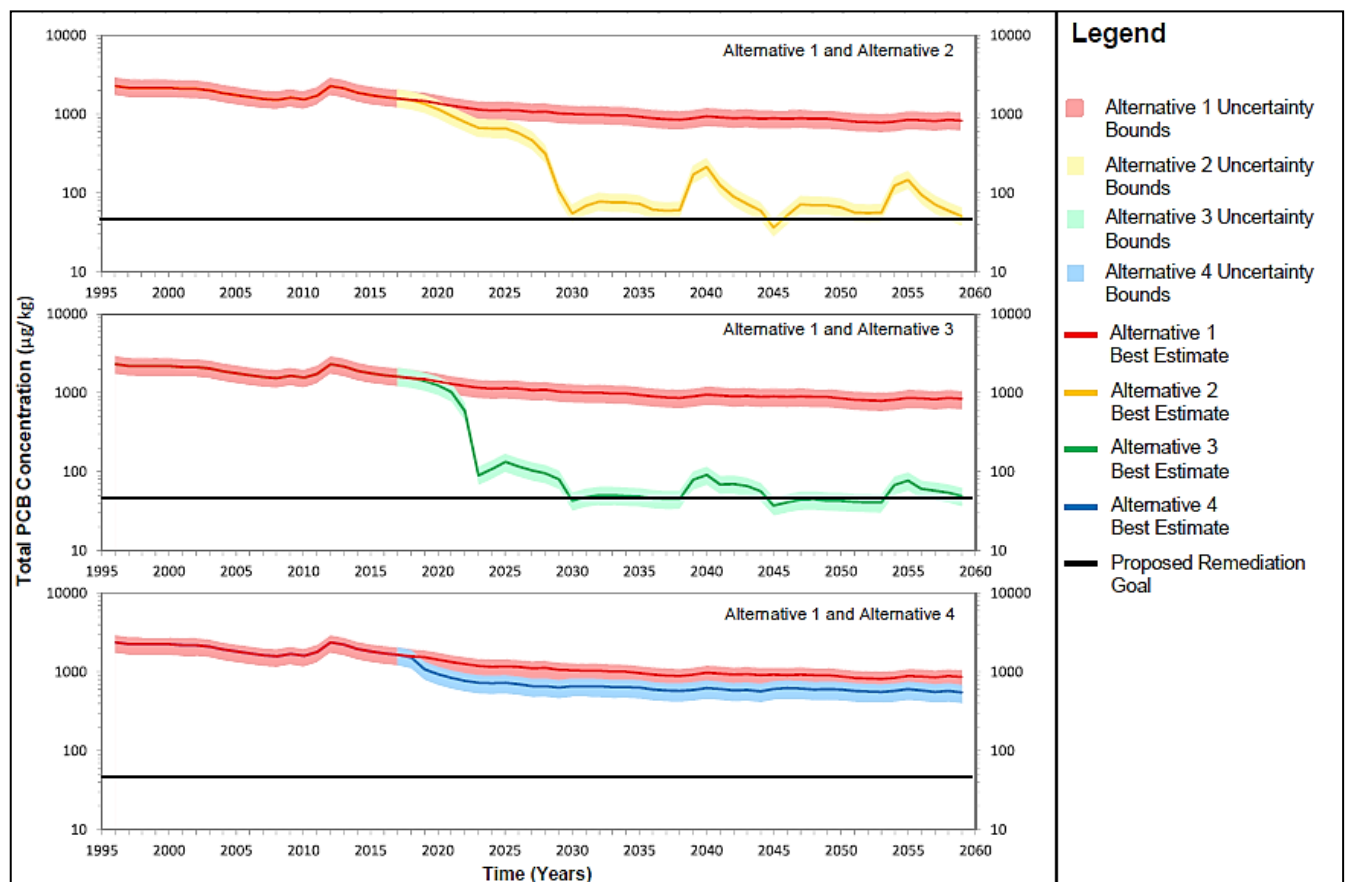
Years to Reach PCB Target Concentration in Fish Averaged Over Entire Upper Hudson River			
Alternative	0.05 ppm PRG	0.2 ppm (1 meal/ month) target	0.4 ppm (1 meal/ 2 months) target
No Action *	>67	>67	>67
MNA*	>67	60 to >67	34 to >67
CAP-3/10/Select	>67	35	21
REM-3/10/Select	>67	35	20
REM-0/0/3	>67	26	11

*Both No Action and MNA results are calculated as a range, with the first value representing the base case, and the second value representing the upper bound. For No Action, none of the fish target concentrations are achieved within the modeled period for either the base case or upper bound; the same limitation applies to MNA for the 0.05 ppm PRG. Therefore, only a single value is shown for these entries on the table.

Lower Passaic River, NJ

The Lower Passaic River FS provides a number of quantitative analyses and presents modeling data that are known to be uncertain (see Exhibit 6 and Attachment C for examples; The Louis Berger Group et al. 2014). These examples may be useful for the Portland Harbor FS, particularly if a natural recovery model is applied.

EXHIBIT 6 AVERAGE CONCENTRATIONS OF TOTAL PCBs IN SURFACE SEDIMENT IN THE STUDY AREAS OF THE FOCUSED FEASIBILITY STUDY: BEST ESTIMATE AND UNCERTAINTY BOUNDS (FIGURE 4-3F IN THE LOUIS BERGER GROUP ET AL. 2014)



Middle River, MD

The authors of the Middle River FS initially conducted a qualitative analysis of alternatives and recognized that the analysis did not "...provide enough detail to distinguish similarities and dissimilarities among the alternatives" (Tetra Tech 2013). Therefore, the authors then conducted a more quantitative analysis that incorporated the qualitative assessments into a multi-criteria decision analysis tool. We are not certain whether a similar multi-criteria decision analysis tool (as described in Attachment D) would be useful for the Portland Harbor FS. However, the Middle River FS does present easily digestible bar charts that compare multiple relevant metrics in a single figure (see Exhibits 7 and 8 for examples). This sort of data presentation may be useful for Portland Harbor.

EXHIBIT 7 COMPARATIVE ANALYSIS - ACHIEVEMENT OF RAO 3 AT THE END OF CONSTRUCTION TO DREDGE VOLUME (FIGURE 7-4 IN TETRA TECH 2013)

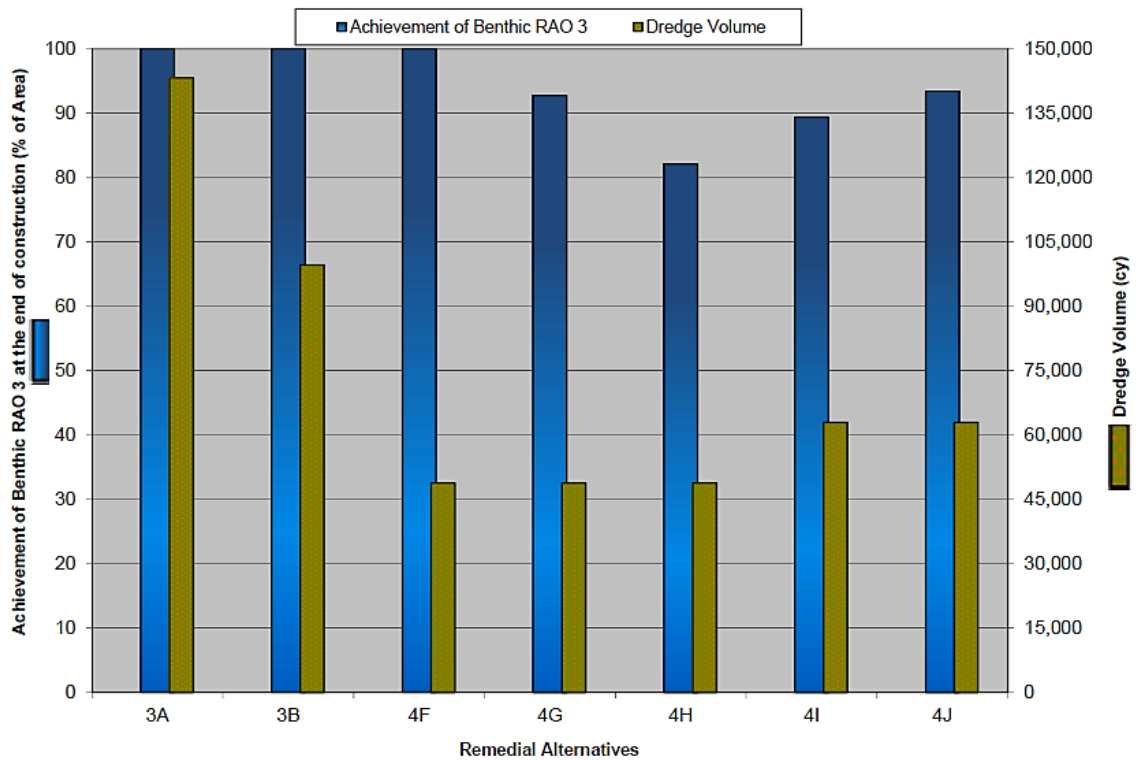
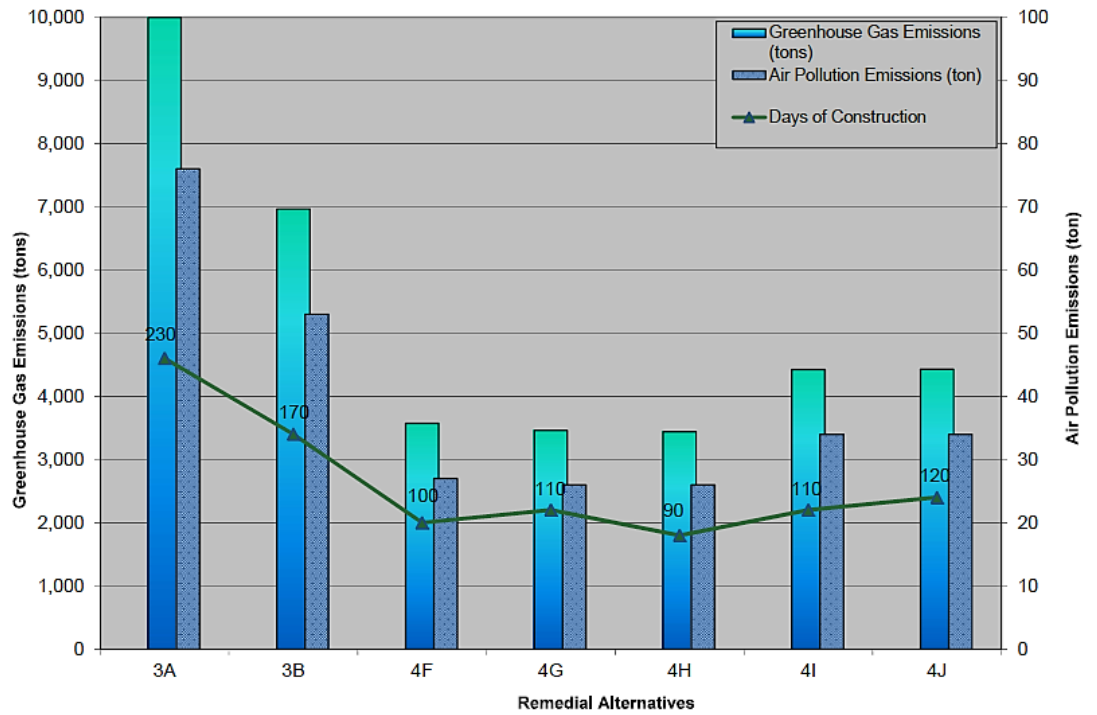


EXHIBIT 8

COMPARATIVE ANALYSIS - ENVIRONMENTAL METRICS (FIGURE 7-6 IN TETRA TECH 2013)



REFERENCES

- AECOM. 2012. Final Feasibility Study Lower Duwamish Waterway Seattle Washington. Prepared by AECOM for submittal to the U.S. Environmental Protection Agency Region 10 and The Washington State Department of Ecology Northwest Regional Office. October 31. Available:
<http://yosemite.epa.gov/R10/CLEANUP.NSF/LDW/Lower+Duwamish+Waterway+Superfund+Site+Technical+Documents>.
- TAMS Consultants, Inc. 2000. Hudson River PCBs Reassessment RI/FS. Phase 3 Report. Feasibility Study. Prepared by TAMS Consultants, Inc. for the U.S. Environmental Protection Agency Region 2 and the U.S. Army Corps of Engineers Kansas City District. Book 1 of 6. Report Text. December. Available;
<http://www3.epa.gov/udson/fs000001.pdf>.
- Tetra Tech, Inc. 2013. Feasibility Study for the Remediation of Sediments Adjacent to Lockheed Martin Middle River Complex, Middle River, Maryland. Prepared for: Lockheed Martin Corporation by Tetra Tech, Inc. July. Available:
<http://www.lockheedmartin.com/content/dam/lockheed/data/corporate/documents/remediation/middle-river/SedimentFeasibilityStudy071513.docx.pdf>.
- The Louis Berger Group, Inc., Battelle, and HDR|HydroQual. 2014. Focused Feasibility Study Report for the Lower Eight Miles of the Lower Passaic River. Prepared for the U.S. Environmental Protection Agency Region 2 and U.S. Army Corps of Engineers, Kansas City District. Available:
<http://passaic.sharepointspace.com/Public%20Documents/2014-03-10%20LPR%20Focused%20Feasibility%20Study%20Report.pdf>.

**ATTACHMENT A:
LOWER DUWAMISH WATERWAY, WA
(AECOM 2012)**

Table 11-6 Disproportionate Cost Analysis – Alternative Benefits Metrics and Scores

Evaluation Criteria			Weighting Factor	Benefit Scoring Basis ^a		Units	Site-wide Remedial Alternatives										
				Score 0	Score 10		2R	2R-CAD	3C	3R	4C	4R	5C	5R	5R-T	6C	6R
1	Overall Protectiveness of Human Health and the Environment		25%	Overall Score			4.0	4.0	5.2	5.0	5.9	5.2	7.0	5.2	5.2	7.5	4.2
1a	Cumulative exposure	Concentration of total PCBs integrated over time. Assume total PCBs is a surrogate for all risk drivers. ^b	50%	1,158	353	(µg/kg dw) yrs	1,035	1,035	950	950	863	903	768	898	898	595	808
	Score 0 represents predicted exposure with natural recovery but without construction (i.e., Alt 1: 1,158 (µg/kg dw) yrs); score 10 represents no action at the start of construction, followed by the asymptote (39 µg/kg dw) from 5 to 45 years following initiation of construction (353 (µg/kg dw) yrs).					Score	1.5	1.5	2.6	2.6	3.7	3.2	4.9	3.2	3.2	7.0	4.4
1b	Cumulative benthic exposure	SQS exceedances integrated over time. ^c	25%	2,055	560	exceedance yrs	1,465	1,465	1,090	1,090	900	975	560	830	830	560	830
	Score 0 represents predicted exposure with natural recovery but without construction (i.e., Alt 1: 2,055 exceedance-yrs); score 10 represents no action at the start of construction, followed by no exceedances from 5 to 30 years following initiation of construction (585 exceedance-yrs).					Score	3.9	3.9	6.5	6.5	7.7	7.2	10.0	8.2	8.2	10.0	8.2
1c	Risks from implementation	Construction time. Assume that impacts during dredging are proportional to construction time when comparing remedial alternatives.	25%	42	0	yrs	4	4	3	6	6	11	7	17	17	16	42
	Score 0 represents construction time for Alt 6R (42 years); score 10 represents no additional construction after the EAAs (i.e., Alt 1: 0 yrs)					Score	9.0	9.0	9.3	8.6	8.6	7.4	8.3	6.0	6.0	6.2	0.0
2	Permanence		20%	Overall Score			2.4	1.9	2.6	3.1	3.7	4.6	4.4	6.1	6.1	5.9	9.5
2a	Reduction in volume of contaminated sediment	Volume of sediment removed from LDW. Performance contingency volume minus volume contained by CAD for Alt 2R-CAD	50%	0	3.90	million cy	0.58	0.27	0.49	0.76	0.69	1.20	0.75	1.60	1.60	1.60	3.90
	Score 0 represents no volume removed after the EAAs (i.e., Alternative 1: 0 cy); score 10 represents the maximum amount of sediment removed for the remedial alternatives (i.e., Alt 6R: 3.9 million cy).					Score	1.5	0.7	1.3	1.9	1.8	3.1	1.9	4.1	4.1	4.1	10.0
2b	Reduction in mobility of hazardous substances	Immobility rating based on the acres weighted by type of technology applied in AOPC 1 normalized to acres in AOPC 1.	50%	Weighted average based on the following:													
		dredge		weighting: 9	acres of AOPC 1	29	5	29	50	50	93	57	143	143	69	164	
		cap/partial dredge and cap (Alternative 2R-CAD includes 24 acres of CAD; acreage subtracted from the dredge area)		weighting: 8	acres of AOPC 1	3	27	19	8	41	14	47	14	14	61	16	
		in situ treatment		weighting: 7	acres of AOPC 1	0	0	5.0	0	8	0	26.5	0	0	25.0	0	
		ENR		weighting: 4	acres of AOPC 1	0	0	5.0	0	8	0	26.5	0	0	25.0	0	
	MNR and VM		weighting: 2	acres of AOPC 1	148	148	122	122	73	73	23	23	23	0	0		
Weightings for each technology are based on best professional judgment. MNR and VM do not score a 0 because monitoring and contingency actions would mitigate mobility of contaminated sediment. Dredging does not score a 10 because some amount of contamination is lost during the dredging process. Therefore, 0 and 10 represent idealized alternatives in which sediments either are not remediated (0), or are removed completely from the LDW (10).						Score	3.2	3.1	4.0	4.2	5.6	6.1	6.8	8.0	8.0	7.7	8.9

Table 11-6 Disproportionate Cost Analysis – Alternative Benefits Metrics and Scores (continued)

Evaluation Criteria					Weighting Factor	Benefit Scoring Basis ^a		Units	Site-wide Remedial Alternatives										
					Score 0	Score 10		2R	2R-CAD	3C	3R	4C	4R	5C	5R	5R-T	6C	6R	
3	Effectiveness Over the Long Term				30%	Overall Score			3.6	3.3	4.2	4.5	5.6	6.3	6.6	8.2	8.2	7.4	9.0
3a	Degree of certainty that the remedial alternative will be successful	Degree of certainty rating based on weighted benefit of remedial technologies normalized to acres of AOPC 1.			80%	Weighted average based on the following:													
		dredge				weighting: 9	acres of AOPC 1	29	5	29	50	50	93	57	143	143	69	164	
		cap/partial dredge and cap (Alternative 2R–CAD includes 24 acres of CAD; acreage subtracted from the dredge area)				weighting: 9	acres of AOPC 1	3	27	19	8	41	14	47	14	14	61	16	
		in situ treatment				weighting: 7	acres of AOPC 1	0.0	0.0	5.0	0.0	8.0	0.0	26.5	0.0	0.0	25.0	0.0	
		ENR				weighting: 6	acres of AOPC 1	0.0	0.0	5.0	0.0	8.0	0.0	26.5	0.0	0.0	25.0	0.0	
	MNR and VM				weighting: 3	acres of AOPC 1	148	148	122	122	73	73	23	23	23	23	0	0	
Weightings for each technology are based on best professional judgment. MNR and VM do not score a 0 because monitoring and contingency actions would mitigate mobility of contaminated sediment. Dredging does not score a 10 because some amount of contamination is lost during the dredging process. Therefore, 0 and 10 represent idealized alternatives in which sediments either are not remediated (0), or are removed completely from the LDW (10).							Score	4.1	4.1	4.8	4.9	6.3	6.6	7.5	8.2	8.3	9.0		
3b	Reliability of ICs and engineering controls used to manage risk	Score inversely proportional to total acres of caps, ENR, MNR, and VM in AOPC 1 (EAAs not included). Assume reliability of ICs and engineering controls is inversely proportional to the area of technologies that leave contamination on site.			20%	180.0	0.0	acres of AOPC 1	151	175	151	130	130	87	123	37	37	111	16
	Score of 0 represents capping, ENR/in situ, MNR, or VM all of AOPC 1; score of 10 represents dredging all of AOPC 1.							Score	1.6	0.3	1.6	2.8	2.8	5.2	3.2	7.9	7.9	3.8	9.1
4	Management of Short-term Risks				15%	Overall Score			8.8	8.3	8.9	8.3	8.1	7.1	7.9	5.8	5.0	5.4	0.0
4a	Implementation risks ^d	Assume risk is proportional to removal and handling volume; equals dredge volume plus placement volume (including capping, ENR, backfill, dredge residuals management, and CAD construction). Assume double handling for Alt 5R-T for half of sediment removed for treatment.			50%	5.1	0	million cy	0.71	1.2	0.76	1.0	1.2	1.6	1.3	2.2	3.0	2.8	5.1
	Score of 0 represents maximum amount of material handled out of the remedial alternatives (i.e., Alt 6R; 5.1 million cy); score 10 represents no material handled (i.e., Alt 1)							Score	8.6	7.6	8.5	8.0	7.6	6.9	7.5	5.7	4.1	4.5	0.0
4b	Effectiveness of protective measures to manage short-term risks	Assume that impacts during dredging are proportional to construction time.			50%	42	0	years	4.0	4.0	3.0	6.0	6.0	11.0	7.0	17.0	17.0	16.0	42.0
	Score 0 represents construction time for Alt 6R (42 yrs); score 10 represents no additional construction after the EAAs (i.e., Alt 1; 0 yrs)							Score	9.0	9.0	9.3	8.6	8.6	7.4	8.3	6.0	6.0	6.2	0.0
5	Technical and Administrative Implementability				5%	Overall Score			6.0	4.0	6.0	6.0	8.0	8.0	8.0	4.0	2.0	4.0	2.0
Best professional judgment based on experience with other remediation sites. Higher score represents more feasible and lower score represents less feasible.																			
6	Consideration of Public Concerns				5%	Overall Score			1.0	0.0	5.0	3.0	5.0	5.0	7.0	7.0	7.0	7.0	8.0
Best professional judgment based on meetings with the public. Higher score represents more public support and lower score represents less public support.																			
7	Total Weighted Benefits					Score			4.2	3.8	5.0	4.9	5.8	5.8	6.5	6.4	6.2	6.6	6.2
8	Cost					\$millions net present value - excluding EAAs			220	200	200	270	260	360	290	470	510	530	810

Notes:

- a. A score of 0 represents the lowest benefit or a poor performing alternative for the given metric. A score of 10 represents the highest benefit or an excellent performing alternative for the given metric. Scores of 0 and 10 do not represent the lowest and highest alternatives in the suite of alternatives, but represent the high and low values shown in the Benefit Scoring Basis columns. The alternatives are scored on a linear scale between these end points.
- b. Total PCB SWAC based on the best estimate (mid input values) BCM output. Cumulative exposure = (Average PCB concentration over 45 years - 39 µg/kg dw) x 45 years.
- c. Cumulative benthic exposure = (Average number of SQS point exceedances over 30 years) x 30 years for representative SMS contaminants.
- d. Implementation risks include release of residual contamination into the water column during dredging, landfill usage, environmental impacts due to transportation of material and mining of sand, worker safety, greenhouse gas emissions, particulate emissions, and other factors. For the purpose of this metric, the volume of material handled is used as a surrogate for these risks.

Alt = alternative; AOPC = area of potential concern; BCM = bed composition model; BPJ = best professional judgment; C = combined technology; CAD = contained aquatic disposal; cy = cubic yards; EAA = early action area; ENR = enhanced natural recovery; ICs = institutional controls; MNR = monitored natural recovery; MTCA = Model Toxics Control Act; PDC = partial dredge and cap; R = removal focused; RAO = remedial action objective; R-CAD = removal-emphasis alternative with contained aquatic disposal; R-T = removal-emphasis alternative with treatment (soil washing); SQS = sediment quality standard; SWAC = spatially-weighted average concentration; VM = verification monitoring

**ATTACHMENT B:
HUDSON RIVER, NY
(TAMS CONSULTANTS 2000)**

Summary of Cancer Risk and Non-Cancer Health Hazard Reductions						
Alternative	Compared to No Action			Compared to MNA		
	Upper Hudson & River Section 1	River Section 2	River Section 3	Upper Hudson & River Section 1	River Section 2	River Section 3
MNA	<2 to 4-fold	<2 to 4-fold	<2 to <3-fold			
CAP-3/10/Select	4 to 8-fold	4 to 9-fold	<2 to 3-fold	2 to 6-fold	3 to 9-fold	<2-fold
REM-3/10/Select	4 to 8-fold	5 to 11-fold	<2 to 3-fold	2 to 7-fold	3 to 11-fold	<2-fold
REM-0/0/3	6 to 11-fold	7 to 16-fold	3 to 4-fold	3 to 9-fold	4 to 16-fold	<2-fold

Ecological Toxicity Quotients - River Otter (Average of 25-Year Time Frame)							
	No Action start year 2008	No Action start year 2009	MNA start year 2008	MNA start year 2009	CAP- 3/10/Select	REM- 3/10/Select	REM- 0/0/3
River Section 1 (RM 189) Modeling time frame is 2008-2032 for CAP-3/10/Select and REM-3/10/Select and 2009-2033 for REM-0/0/3							
LOAEL	24-30	23-29	9.7-15	9.1-14	5.3	5.2	3.7
NOAEL	240-300	230-290	97-150	91-140	53	52	37
River Section 2 (RM 184) Modeling time frame is 2009-2033 for CAP-3/10/Select and REM-3/10/Select and 2011-2035 for REM-0/0/3							
LOAEL	14-27	12-26	9.2-24	7.8-23	3.5	2.9	1.8
NOAEL	140-270	120-260	92-240	78-230	35	29	18
River Section 3 (RM 154) Modeling time frame is 2010-2034 for CAP-3/10/Select and REM-3/10/Select and 2012-2036 for REM-0/0/3							
LOAEL	2.4	2.3	1.2	1.1	0.87	0.86	0.62
NOAEL	24	23	12	11	8.7	8.6	6.2
Notes: TQs above the target level of 1.0 are shown in boldface type. Range of years calculated using bounding estimates are presented for the No Action and MNA alternatives.							

**ATTACHMENT C:
LOWER PASSAIC RIVER, NJ
(THE LOUIS BERGER GROUP ET AL. 2014)**

Table 5-1 Summary of Total Cancer Risks and Child Health Hazards

	Alternative 1 No Action ¹			Alternative 2 Deep Dredging with Backfill ¹			Alternative 3 Capping with Dredging for Flooding and Navigation ¹			Alternative 4 Focused Capping with Dredging for Flooding ¹		
Year	2019			2030			2023			2020		
Fish												
	Risk ¹	Hazard (Adult)	Hazard (Child)	Risk ¹	Hazard (Adult)	Hazard (Child)	Risk ¹	Hazard (Adult)	Hazard (Child)	Risk ¹	Hazard (Adult)	Hazard (Child)
TCDD TEQ (D/F)	2.00E-03	38	65	2.00E-04	3	10	2.00E-04	3	7	1.00E-03	20	35
TCDD TEQ (PCBs)	1.00E-03	27	50	2.00E-04	4	7	2.00E-04	3	6	1.00E-03	19	33
Total PCBs	5.00E-04	24	45	4.00E-05	2	4	3.00E-05	2	4	3.00E-04	15	27
4,4'-DDD	6.00E-06	ND	ND	3.00E-06	ND	ND	2.00E-06	ND	ND	5.00E-06	ND	ND
4,4'-DDE	9.00E-06	ND	ND	5.00E-06	ND	ND	4.00E-06	ND	ND	8.00E-06	ND	ND
4,4'-DDT	8.00E-06	0.1	0.2	4.00E-06	0.05	0.09	4.00E-06	0.05	0.08	7.00E-06	0.09	0.1
Total Chlordane	3.00E-06	0.04	0.06	3.00E-06	0.03	0.05	3.00E-06	0.03	0.05	3.00E-06	0.04	0.06
Methylmercury	ND	1	2	ND	0.6	1	ND	0.6	1	ND	1	2
Total	4.00E-03	90	163	5.00E-04	10	22	4.00E-04	8	18	2.00E-03	55	97
Crab												
	Risk ¹	Hazard (Adult)	Hazard (Child)	Risk ¹	Hazard (Adult)	Hazard (Child)	Risk ¹	Hazard (Adult)	Hazard (Child)	Risk ¹	Hazard (Adult)	Hazard (Child)
TCDD TEQ (D/F)	9.00E-04	17	29	8.00E-05	1	4	7.00E-05	1	3	5.00E-04	9	15
TCDD TEQ (PCBs)	9.00E-04	18	32	3.00E-04	5	8	2.00E-04	4	7	7.00E-04	14	24
Total PCBs	1.00E-04	5	10	2.00E-05	1	2	2.00E-05	1	2	8.00E-05	4	7
4,4'-DDD	6.00E-07	ND	ND	1.00E-07	ND	ND	1.00E-07	ND	ND	4.00E-07	ND	ND
4,4'-DDE	1.00E-06	ND	ND	3.00E-07	ND	ND	2.00E-07	ND	ND	8.00E-07	ND	ND
4,4'-DDT	8.00E-07	0.01	0.02	2.00E-07	0.003	0.005	2.00E-07	0.002	0.004	7.00E-07	0.008	0.01
Total Chlordane	2.00E-07	0.002	0.004	2.00E-07	0.002	0.004	2.00E-07	0.002	0.004	2.00E-07	0.002	0.004
Methylmercury	ND	0.3	0.5	ND	0.1	0.2	ND	0.1	0.1	ND	0.2	0.4
Total	2.00E-03	40	71	4.00E-04	7	15	3.00E-04	6	13	1.00E-03	27	47

Notes:

DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane; D/F = Dioxins/furans; ND = non-detect; PCB = polychlorinated biphenyl;

TCDD TEQ = Tetrachlorodibenzo-p-dioxin Toxic Equivalency Quotient.

1. Sum of individual receptor risk results for the adult and the child.

**ATTACHMENT D:
MIDDLE RIVER, MD
(TETRA TECH 2013)**

7.1.1 Qualitative Comparative Analysis

A qualitative comparative analysis evaluated the relative overall ranking of each remedial alternative based on the detailed evaluation conducted in Section 6. A five-star ranking system (corresponding to low, low-medium, medium, medium-high, and high levels) assessed the relative performance of each alternative. The evaluation framework follows the CERCLA threshold, balancing, and modifying criteria, which are represented by one or more individual metrics. Two levels of evaluation criteria were established to incorporate those metrics: Level 1 criteria are the major threshold, balancing and modifying criteria; Level 2 criteria include factors considered in evaluating the Level 1 criteria.

This qualitative framework and the evaluation are presented in Table 7-1, along with a discussion regarding performance of the alternatives under each CERCLA criterion. Some Level 2 criteria were evaluated based on the metrics for each alternative (e.g., estimated time to meet remedial action objectives [RAOs], removal volume, years of construction, depleted resources of backfill materials and landfill). A qualitative comparison was performed and a star ranking was assigned for each Level 1 criterion. A summary at the bottom of the table shows the overall star ranking of each alternative. The general outcome of the qualitative comparison is that the combined-action alternatives scored better than removal alternatives and the No Action alternative, and Alternatives 4F, 4G, and 4J scored the best among the combined-action alternatives (See discussion in Section 7.5).

The qualitative comparison produces a fairly similar ranking for many of the alternatives, and does not provide enough detail to distinguish similarities and dissimilarities among the alternatives, specifically within the combined-action alternatives. A more quantitative analysis method (i.e., multi-criteria decision analysis) provided a basis for further evaluation and distinguishing differences among the alternatives. This method allowed consideration of multiple factors under each CERCLA criterion by assigning scores and weightings to these metrics. The methodology for the multi-criteria decision analysis and detailed discussion of the comparative analysis are presented in the following sections.

7.1.2 Multi-Criteria Comparative Analysis

A multi-criteria comparative decision analysis was performed to support selection of the recommended alternative. Multi-parameter analysis tools were developed based on the multi-criteria

decision analysis, which offer a scientifically sound decision framework for managing contaminated sediments. This method is useful because criteria such as environmental benefits, impacts, risk, economics, and stakeholder participation cannot be easily condensed into simple evaluation matrices. Other benefits associated with a multi-parameter analysis tool include having the decision criteria for remedy selection, the weighting of each criterion considered, and the score applied to each remedial alternative clearly defined and readily available for review when using this method.

In this FS, the multi-parameter analysis tool Criterion Decision Plus® (CDP) was used to weight and score remedial alternatives for the MRC site. Criterion Decision Plus® is a decision analysis tool that uses decision-making techniques such as the analytical hierarchy process, the Multi-Attribute Utility Theory, and the simple multi-attribute rating technique that is incorporated into the tool (InfoHarvest, 2001). To build the decision hierarchy and incorporate all the decision factors, each CERCLA evaluation criterion is represented by one or more individual metrics. To account for those metrics, up to three levels of evaluation criteria were established: Level 1 criteria are the major balancing and modifying criteria; Level 2 criteria have factors considered in evaluation of Level 1 criteria; and Level 3 has further subcomponents with which to evaluate the Level 2 criteria. The framework for comparative evaluation of alternatives is summarized in Table 7-2, and an illustration of the decision analysis framework and interactions among the various levels of criteria is in Figure 7-2.

Overall protection of human health and the environment and compliance with ARARs are threshold criteria, and all alternatives would meet these criteria; they were therefore not included in the CDP evaluations. The contribution of the balancing and modifying CERCLA criteria to the overall evaluation was calculated by applying a weighting factor to each criterion. An environmental criterion was also added to support short-term effectiveness metrics among the alternatives where the differences in energy use, air emissions, and impacts to water resources of a remedy were evaluated. The criterion was added to be consistent with Lockheed Martin's policy to implement green and sustainable remediation, and the USEPA green remediation policy to enhance the environmental benefits of federal cleanup programs by promoting sustainable technologies and practices.

For the primary balancing criteria, a 20% weight was assigned to the criteria of long-term effectiveness, permanence, and implementability. A weight of 10% was assigned to the reduction